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The role of reconstructive surgery in the management of war wounds

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Reconstructive surgery can be used within a framework of management of war wounds by basic principles. It falls into three groups:

i. **Primary (emergency) reconstruction; performed as part of initial surgery and as a life-saving procedure.**
ii. **Delayed primary (essential) reconstruction; performed at the time of delayed closure.**
iii. **Elective or non-essential reconstruction.**

All surgeons involved with the early management of war wounds should be prepared to perform primary and delayed primary reconstruction.

The International Committee of the Red Cross (ICRC) has surgical hospitals for victims of war in seven countries. The largest operations are, at present, on both sides of the Afghan and Cambodian conflicts. The surgeons in these hospitals are from civilian practice. They work without specialist referral and have the responsibility of continued care of war wounded patients.

The necessity of management of war wounds by basic principles cannot be overemphasised. Complete and careful wound excision, leaving the wound open and delayed primary closure are safe and effective.

When particularly large or serious wounds are encountered, skin or muscle flaps may be necessary to close the wound. In the countries where ICRC works, general surgeons find it useful to have some reconstructive procedures in their repertoire which can be performed within the framework of management by basic principles. The purpose of this article is to clarify the role of reconstructive surgery.

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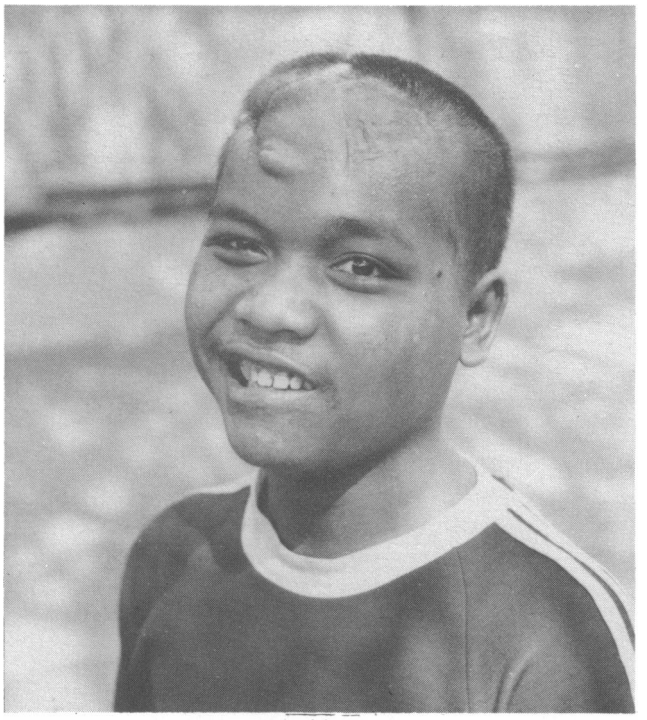
Primary (emergency) reconstructive surgery

Most war wounds require excision *(1,2)*. This is the most important part of their management. Initial wound surgery might leave brain, lung or repaired vessels exposed. Standard texts *(3,4)* recognise the importance of immediate closure of these wounds, and that in the presence of even moderate tissue loss this is impossible by direct means. The surgeon performing initial wound surgery might have to cover vital structures with a skin or muscle flap. There is little advice about how this might be achieved.

Penetrating craniocerebral injuries are common in modern warfare. Their operative management aims to save the patient's life and prevent subsequent brain infection. It involves soft tissue wound excision, craniectomy to gain access to the wound track and extraction of haematoma, pulped brain and bone fragments. Cover of the exposed brain wound by normal skin is essential to prevent death or brain fungus *(5,6)*. Scalp rotation or transposition flaps are best and most easily raised beneath the galea and positioned with skin sutures catching all layers. Pericranium exposed in the secondary defect is covered by a split-skin graft (Fig. 1). A potential advantage of moving the galea with the skin flap is that when laid on an unrepaired dural defect it could act as a separate layer which can be left on the brain surface in the event of later cranioplasty. The author does not repair the dura after brain débridement.

Tangential wounds of the chest wall are made by bullets or fragments from explosive weapons. Large defects can have surprisingly little underlying lung damage. The lung is collapsed and excision of these wounds may leave a defect that is too large to close directly. To avoid respiratory failure and empyema the lung must be expanded as soon as possible. This requires airtight closure of the chest wall. Such a defect is well



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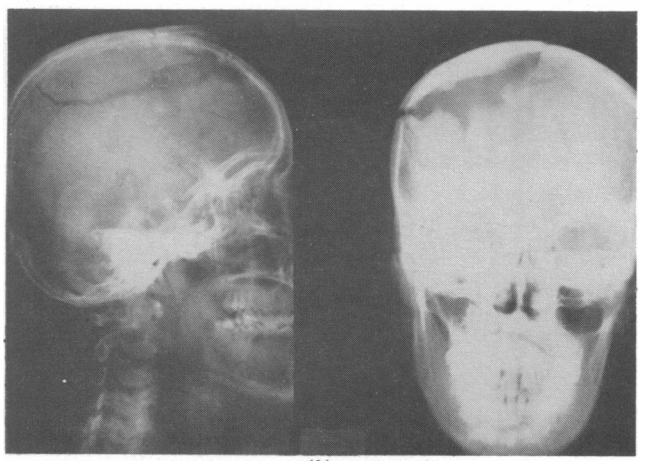

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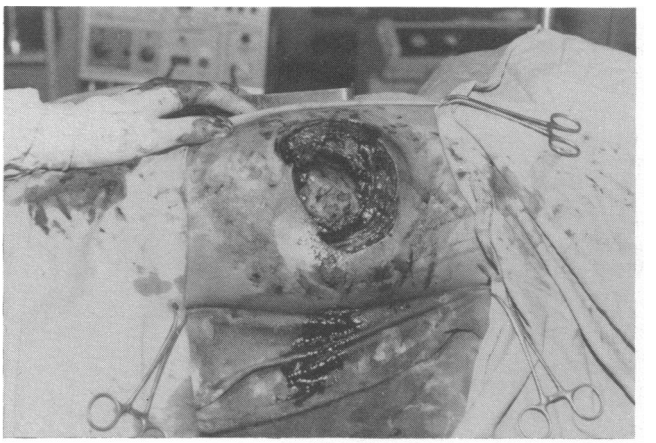
Figure 1. (*a*) A patient who received a tangential gunshot wound of the head. The exposed brain and bone defect were covered by a scalp transposition flap. Photograph taken 3 weeks after admission. (*b*) Skull radiographs of the patient shown in Fig. 1(*a*).



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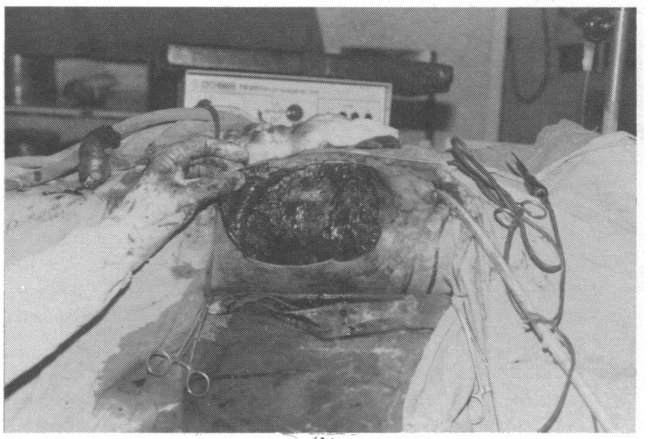

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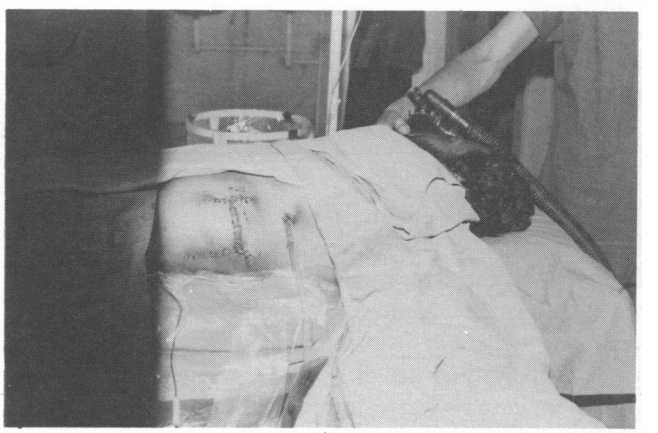

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Figure 2. (*a*) Operative photograph of the left chest wall. The surgeon's hand is resting on the costal margin; the patient's head is beneath the drapes on the right. The chest wall defect was caused by a tangential missile wound and subsequent excision of dead muscle and fragments of rib. The dome of the left hemidiaphragm is visible inside the wound, the lung having collapsed. (*b*) The defect seen in Fig. 2(*a*) covered by a latissimus dorsi muscle flap swung anteriorly. A large-bore chest drain has been placed above the wound. (*c*) The wound seen at delayed primary closure of skin over the muscle flap shown in Fig. 2(*b*).

sealed by a bulky muscle flap; latissimus dorsi is the muscle of choice as it can be moved to cover most parts of the chest wall (Fig. 2). All or part of this muscle is easily mobilised on a superior base to give generous and secure cover of the defect. There is no need to move overlying skin with it. Skin cover can be achieved at delayed closure by suture or skin graft. Thoracic cavity drainage is routine and full expansion of the lung is usually achieved within 48 h. The muscle flap shows paradoxical respiratory movement, but there is never obvious disability from this.

In World War II, vascular injuries were treated by ligation alone. This resulted in a high rate of limb amputation (*7*). In subsequent wars, more rapid evacuation and vascular specialist availability was reported to reduce the number of amputations (*8*). Most repairable vessel injuries are part of wounds with minimal tissue

damage. Subsequent cover of the repair is not a great problem. When there is vessel damage as part of a larger wound, and the victim survives, the surgeon must excise the wound and repair the vessels. This inevitably means leaving the vascular repair crossing a cavity. Cover with skin alone may not suffice. Schramek and Hashmonai *(9)* acknowledge this but do not really provide a solution. They state that "wound débridement back to bleeding muscle is imperative . . . good judgement is required to retain enough viable tissue to provide a bed and cover for the vascular repair." Therefore this problem, although rare, is an indication for primary closure by myoplasty. Latissimus dorsi covers axillary and brachial vessels. Gracilis, among others, is suitable for femoral vessel cover. The gastrocnemius is an obvious choice for the popliteal vessels. This muscle can be mobilised distally and moved without overlying skin. Delayed closure of skin is routine.

Severe maxillofacial wounds do not require immediate reconstruction. Priority is given to airway protection, wound excision and closure of the oral cavity. However, primary closure of skin on the face does not transgress basic principles, and so a skin flap in one stage, or as the first of multiple stages, may be performed. The advisability of this will depend on the expertise of the surgeon and the time available.

There is no place for primary nerve repair in war surgery. This should be done when the wound is healed. Unfortunately, later nerve repair is rarely feasible in ICRC hospitals.

Delayed primary (essential) reconstruction

Limb wounds generate approximately 75% of the workload of a hospital for war injured *(10)*. Long bone fractures and exposed joints are common and difficult problems. The first stage in their management is correct wound excision, which lessens the need for, and yet facilitates, later reconstruction. Closure of limb wounds by suture, skin graft or reconstruction is best after 4 or 5 days at the time of the first dressing change *(1,11–13)*. The delay allows re-excision of the wound if incompletely excised at the first operation. Simultaneous planning and performing of external skeletal fixation and soft tissue reconstruction are also best performed at delayed closure. This ensures the pin sites do not impede the raising or moving of the flap *(14)*. These procedures can then be carried out on a routine list and not as emergencies, when time and staff may be in short supply. Delayed closure by myoplasty to cover the tibial stump in below-knee amputations for mine injuries has proved effective *(15)*.

The limb wounds that most commonly require soft tissue reconstruction in war surgery expose the tibia, knee joint, forearm and wrist. Flaps incorporating skin, fascia or muscle can be used, depending on the expertise of the surgeon. Muscle flaps are preferred because the bone is protected from infection *(16,17)* and a good environment for callus formation and bone graft results.

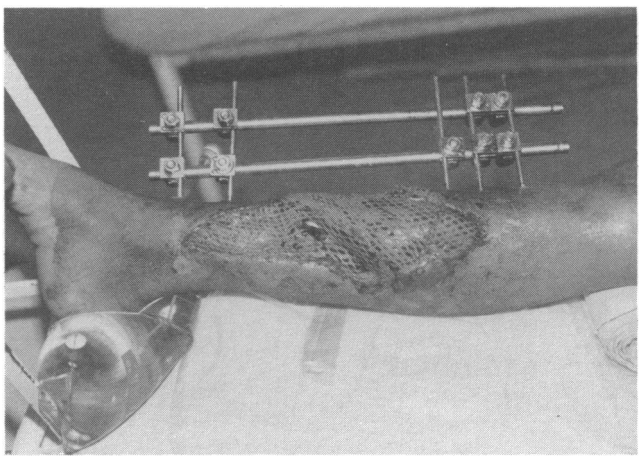


Figure 3. Photograph of the medial side of the right leg. The tibial fracture has been fixed by external skeletal fixation and a soleus muscle flap swung anteromedially to cover the fracture. The muscle flap has been covered by a meshed skin graft. The fixation, muscle flap and skin graft were performed at delayed closure.

The upper third of the tibia and the knee joint are easily covered by gastrocnemius muscle flaps; the medial muscle is preferable because it is longer and its mobilisation does not endanger the common peroneal nerve. The soleus muscle lends itself to the middle third of the tibia. The muscle flaps can be covered by split-skin grafts (Fig. 3). They are robust and require minimal expertise. They are the most commonly utilised flaps in war surgery.

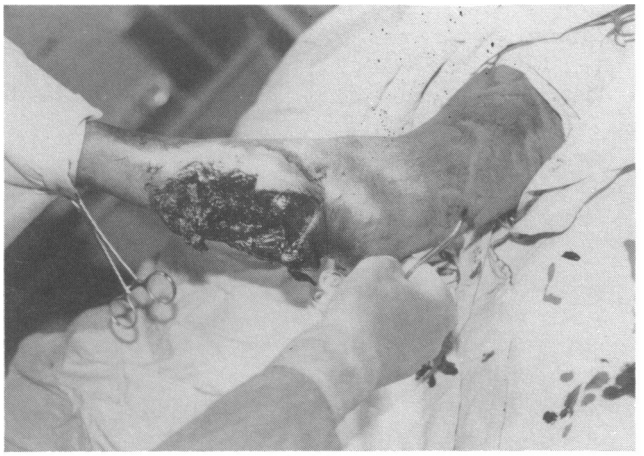
For the general surgeon there is no reliable, local flap to cover war wounds of the lower third of the tibia. However, with mine or missile injuries of this part, the foot is rarely viable when large soft tissue defects accompany comminuted fractures.

Fasciocutaneous flaps as transposition or cross leg flaps can also be used. They do not achieve the same as the muscle flaps in terms of wound disinfection. Cross leg flaps are unpopular with both surgeon and patient because they require a period of immobility and at least two stages. They have the advantage that they can reach the whole leg.

Forearm defects can be covered by an abdominal skin flap (Fig. 4); hand and wrist wounds by a groin flap. In reality, these are infrequently performed because, compared with the lower limb, the return to function of the upper limb, after injury by a weapon of war, is limited.

Elective or non-essential reconstructive surgery

Armed conflict generates an enormous number of chronic, non-life-threatening problems for which reconstructive surgery is the only solution. Examples are burn contracture release, correction of severe malunion, nerve repair, tendon transfer for nerve lesions and myoplasty for chronic osteomyelitis. The history of plastic surgery is strongly linked with reconstruction of the war injured



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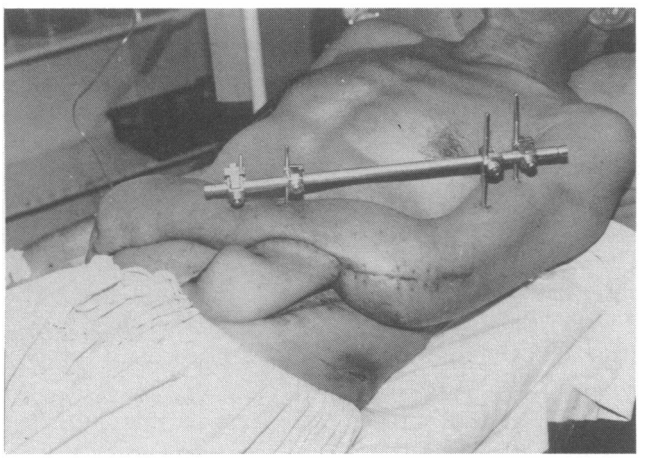

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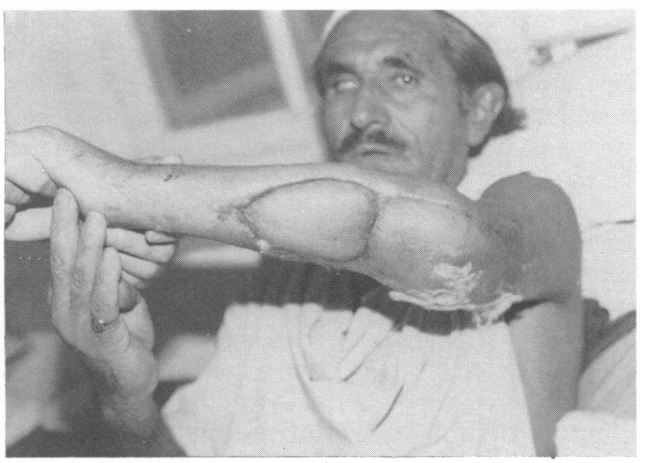

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Figure 4. (*a*) Photograph of a left arm with a severe gunshot wound. The entry is indicated by the artery forceps. (*b*) The arm shown in Fig. 4(*a*) with external skeletal fixation and an abdominal skin flap to cover the defect. Both procedures performed at delayed closure. Photograph taken 2 weeks after admission. (*c*) The result of the flap shown in Fig. 4(*b*). A bone graft has been placed beneath the flap and the forearm is solid. Photograph taken 2 months after admission.

face (*18*). The practical and philosophical implications of performing elective reconstructive surgery in the situations where the ICRC is working are considerable. At present, only the most severe and disabling problems are dealt with. The surgical aspects are beyond the scope of this article.

Recommendations

Civilian surgeons undertaking war surgery tend to put greater emphasis on their own specialist background and assume that problems can be solved within that specialty. They must recognise the different pathology and that careful and complete wound excision is the key to wound healing. Specialist skills may prove useful in certain cases.

Surgeons performing either initial surgery or delayed closure of war wounds are unlikely to be plastic surgeons. There are a limited number of reconstructive procedures which can be used to great advantage within management by well-proven basic principles. The most useful are: gastrocnemius, soleus and latissimus dorsi muscle flaps, scalp rotation and transposition flaps, abdominal and groin skin flaps. Surgeons who manage war wounds without a formal training in plastic surgery are advised to familiarise themselves with these procedures.

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Assessor's comment

This is a most timely paper which is based upon the author's personal experience with the ICRC Hospitals which have such a wide experience in the surgery of victims of war. There is a proper emphasis on the fact that thorough excision of all dead tissue from the wound is the bedrock of practice on which delayed primary surgery and reconstruction can be built. The principles of surgery of war wounds are simple, easy to understand and teach but, of course, the practice in a wounded patient may be very difficult. Robin Coupland defines the problem areas of immediate cover of exposed brain, lung and blood vessels at the primary operation of wound excision. Another problem area is that of reconstruction at the time of delayed primary closure. Most texts simply say 'swing a flap' or 'cover with muscle', but this paper covers these areas in a clear, concise and informative style and will be of value to any surgeon embarking on the management of the wounds of war.

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